Application Considerations

Load characteristics, performance requirements, and coupling techniques need to be understood before the designer can select the best motor/drive for the job. While not a difficult process, several factors need to be considered for an optimum solution. A good designer will adjust the characteristics of the elements under his control –including the motor/drive and the mechanical transmission type (gears, lead screws, etc.) – to meet the performance requirements. Some important parameters are listed below.

Torque

Rotational force (ounce-inches or pound-inches) defined as a linear force (ounces) multiplied by a radius (inches). When selecting a motor/drive, the torque capacity of the motor must exceed the load. The torque a motor can provide may vary with its speed. Individual speed/torque curves should be consulted by the designer for each application.

Inertia

An object's inertia is a measure of its resistance to change in velocity. The larger the inertial load, the longer it takes a motor to accelerate or decelerate that load. However, the speed at which a motor rotates is independent of inertia. For rotary motion, inertia is proportional to the mass of the object being moved times the square of its distance from the axis of rotation.

Friction

All mechanical systems exhibit some frictional force, and this should be taken into account when sizing the motor, as the motor must provide torque to overcome any system friction. A small amount of friction is desirable since it can reduce settling time and improve performance.

Torque-to-Inertia Ratio

This number is defined as a motor's rated torque divided by its rotor inertia. This ratio is a measure of how quickly a motor can accelerate and decelerate its own mass. Motors with similar ratings can have different torque-to-inertia ratios as a result of varying construction.

Load Inertia-to-Rotor Inertia Ratio

For a high performance, relatively fast system, load inertia reflected to the motor should generally not exceed the motor inertia by more than 10 times. Load inertias in excess of 10 times the rotor inertia can cause unstable system behavior and inefficent power usage.

Torque Margin

Whenever possible, a motor/drive that can provide more motor torque than the application requires should be specified. This torque margin accommodates mechanical wear, lubricant hardening, and other unexpected friction. Resonance effects, while dramatically reduced with Compumotor's microstepping systems, can cause a stepper motor's torque to be slightly reduced at some speeds. Selecting a motor/drive that provides at least 50% margin for steppers, and 20% for servos, above the minimum needed torque is good practice.

Velocity

Because available torque varies with velocity, motor/drives must be selected with the required torque at the velocities needed by the application. In some cases, a change in the type of mechanical transmission used is needed to achieve the required performance.

Resolution

The positioning resolution required by the application will have an effect on the type of transmission used and the motor resolution. For instance, a leadscrew with 4 revolutions per inch and a 25,000-step-per-revolution motor/drive would give 100,000 steps per inch. Each step would then be 0.00001 inches.

Duty Cycle

Servo motors can produce peak torque for *short* time intervals as long as the RMS or average torque is within the motor's continuous duty rating. To take advantage of this feature, the application torque requirements over various time intervals need to be examined so RMS torque can be calculated.

Solving Duty Cycle Limitation Problems

Operating a motor beyond its recommended duty cycle results in excessive heat in the motor and drive. This can destroy the motor and drive package. The duty cycle may be increased by providing active cooling to the drive and the motor. A fan directed across the motor and another directed across the drive's heatsink will result in increased duty cycle capability.

Note: Motors will run at case temperatures up to 100°C (212°F)—temperatures hot enough to burn individuals who touch the motors.

To Improve Duty Cycle:

- Use a motor large enough for the application
- Mount the drive with heatsink fins running vertically
- Fan cool the motor
- Fan cool the drive
- Put the drive into REMOTE POWER SHUTDOWN when it isn't moving, or reduce current (Steppers Only)
- Reduce the peak current to the motor (if possible)

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Application Considerations (continued)

Accuracy

An accuracy specification defines the maximum error in achieving a desired position. Some types of accuracy are affected by the application. For example, repeatability will change with the friction and inertia of the system the motor is driving.

Accuracy in a rotary motor is usually defined in terms of arc minutes or arc seconds (the terms arc second and arc minute are equivalent to second and minute, respectively). There are 1,296,000 seconds of arc in a circle. For example, an arc second represents 0.00291 inches of movement on a circle with a 50-foot radius. This is equivalent to about the width of a human hair.

Stepper Accuracy

There are several types of performance listed under Compumotor's motor specifications: repeatability, accuracy, relative accuracy, and hysteresis.

Repeatability

The motor's ability to return to the same position from the same direction. Usually tested by moving the motor one revolution, it also applies to linear step motors moving to the same place from the same direction. This measurement is made with the motor unloaded, so that bearing friction is the prominent load factor. It is also necessary to ensure the motor is moving to the repeat position from a distance of at least one motor pole. This compensates for the motor's hysteresis. A motor pole in a Compumotor is 1/50 of a revolution.

Accuracy

Also referred to as absolute accuracy, this specification defines the quality of the motor's mechanical construction. The error cancels itself over 360° of rotation, and is typically distributed in a sinusoidal fashion. This means the error will gradually increase, decrease to zero, increase in the opposite direction and finally decrease again upon reaching 360° of rotation. Absolute accuracy causes the size of microsteps to vary somewhat because the full motor steps that must be traversed by a fixed number of microsteps varies. The steps can be over or undersized by about 4.5% as a result of absolute accuracy errors.

Relative Accuracy

Also referred to as step-to-step accuracy, this specification tells how microsteps can change in size. In a perfect system, microsteps would all be exactly the same size, but drive characteristics and the absolute accuracy of the motor cause the steps to expand and contract by an amount up to the relative accuracy figure. The error is not cumulative.

Hysteresis

The motor's tendency to resist a change in direction. This is a magnetic characteristic of the motor, it is not due to friction or other external factors. The motor must develop torque to overcome hysteresis when it reverses direction. In reversing direction, a one revolution move will show hysteresis by moving the full distance less the hysteresis figure.

Servo & Closed-Loop Stepper Accuracy

Repeatability, accuracy and relative accuracy in servos and closed-loop stepper systems relate as much to their feedback mechanisms as they do to the inherent characteristics of the motor and drive.

Servos

Compumotor servos use either encoders or resolver feedback to determine their resolution and position. It is essentially the resolution of the device reading the feedback position that determines the highest possible accuracy in the system. The positional accuracy is determined by the drive's ability to move the motor to the position indicated by the resolver or encoder. Changes in friction, inertia, or tuning parameters will adversely affect the accuracy of the system.

Closed-Loop Steppers

Compumotor closed-loop stepper systems use an encoder to provide feedback for the control loop. The encoder resolution determines the system's accuracy. When enabled, the drive/controller attempts to position the motor within the specified deadband from the encoder. Typically, this means the motor will be positioned to within one encoder step. To do this satisfactorily, the motor must have more resolution than the encoder. If the step size of the motor is equal to or larger than the step size of the encoder, the motor will be unable to maintain a position and may become unstable. Compumotor recommends a minimum of a 4:1 ratio. In a system with adequate motor-to-encoder resolution, the motor is able to maintain one encoder step of accuracy with great dependability. This is a continuous process that will respond to outside events that disturb the motor's position.